Grazer effects on plant species richness and tree debarking within orchard pastures

Schmitz A. , López-Sánchez A. , Roig S. and Isselstein J.

Abstract

Orchards are traditional agroforestry elements in agricultural landscapes and valuable for nature conservation in Europe. However, their diversity is endangered due to farmland intensification or abandonment. Grazing management promotes plant species diversity but grazers are suspected to harm trees through debarking. We studied 42 orchards within the Rhenish uplands (Germany) and compared horses, cattle and sheep grazing. We analysed how grassland diversity is promoted by the presence of trees and modified by grazing management, as well as how grazers may impact trees. Plant species richness benefited from tree presence, but was not affected by tree-cover and only slightly by grazer species, whereas grazing intensity showed significant negative effects. All grazer species significantly increased recent debarking in the absence of individual tree-protection. Therefore, maintaining species diversity and long-term tree persistence in orchards does not primarily depend upon grazer species, but more especially on grazing intensity and tree-protection.

Keywords: orchards, agroforestry, grazer species, debarking

Introduction

Orchards are traditional agroforestry elements in agricultural landscapes, combining grassland and planted fruit trees. They are of great importance for biodiversity conservation, but endangered due to farmland intensification or abandonment (Garbarino and Bergmeier, 2014). Grazing evolved as an important management strategy over the last decades. However, research on grazing and debarking in German orchards is lacking. Since orchards have usually not experienced grassland intensification practices, they have relatively high plant species richness (SR). Furthermore, the presence of scattered trees in grasslands is known to promote niches with considerable variation in light availability and soil properties which enables species coexistence (Garbarino and Bergmeier, 2014). Therefore, in this study, we tested the hypotheses that (1) plant SR in grassland is increased by tree presence and depends on tree-cover. Grazers affect plant SR due to specific selectivity, nutrient deposition and trampling, which is known to differ between grazers and to depend on grazing intensity (Rigueiro-Rodríguez *et al.,* 2009; Wrage *et al.*, 2011). Hence, we hypothesized that (2) plant SR differs between grazer species and is affected by grazing intensity. As grazers are suspected to harm trees due to browsing and debarking (Plieninger *et al.*, 2015), we tested the hypotheses that (3) grazers species differ in the amount of recent debarking depending on grazing intensity and tree-cover, and that (4) tree-protection helps to avoid debarking.

Materials and methods

In 2014, we studied managed orchards of 40 farmers within the Rhenish uplands (Germany). 42 paddocks were arranged in 14 triplets, while each triplet comprised three neighbouring paddocks of similar site conditions (soil, slope, altitude) grazed by cattle, horse and sheep, respectively. To ensure vegetation equilibrium, only paddocks were chosen that experienced the same management since at least 5 years.

At all sites a subplot of 1,250 m^2 with at least 3 trees was randomly established. In addition, two transects (2×35 m) were chosen for vegetation analysis, one diagonal through the subplot, including all tree-introduced microhabitats (shady areas under crowns, ecotones) and the other located on the same paddock but not influenced by trees at all. All grassland plant species in transects were identified. SR per paddock was defined as cumulative number of species of both transects. Further, a regional set of species indicating high-nature-value (HNV) (BfN, 2016) was used to obtain information on biodiversity value of the study sites.

Recent debarking (less than 1 year) was estimated for all trees within each subplot as a percentage of the trunk. Protectors were recorded as presence/absence data. Tree-cover was estimated by digitizing tree crowns (in m^2) on an aerial picture (geobasis.nrw, 2012) using ArcGIS10.3 and related to the ground area of the subplot. Information on site management was obtained by interviewing farmers. Grazing intensity was estimated as live-weight unit grazing days per hectare and year (LUGD ha^{-1} a^{-1}, with one livestock unit = 500 kg). Statistics were performed in R 3.2.2 applying mixed effects models, lme in nlme package for vegetation data and lmer in lme4 package for recent debarking data. In all models we used livestock, LUGD ha^{-1} a^{-1}, and tree cover as fixed effects. Transect area and protector presence, were used as additional fixed effects for vegetation and recent debarking analysis respectively. In all models site was nested in triplet as random term. Recent debarking was fitted to binomial error distribution with a logit link. Most important fixed effects were obtained using the model averaging approach (MuMIn Package) best models were selected by AICc by delta <2. Residuals were visually checked for heterogeneity in final models.

Results and discussion

On 42 orchards, we observed a total of 145 grassland species. Tree-cover varied between 10 and 60%, with a mean of 23% and a significantly higher cover on cattle pastures. Mean grazing intensity did not differ significantly between grazer species but showed remarkable variability especially on horse pastures with mean 572 LUGD ha^{-1} a^{-1} (±464 standard deviation). Directly comparing vegetation of transects in tree-areas and areas not influenced by trees on the same paddocks, models showed significantly higher SR in tree-areas (Figure 1B).

Trees introduce heterogeneous microhabitats which enable species with different requirements to sustain, which Schmiedgen *et al.* (2016) confirmed in the current proceedings using the same paddocks following a design focusing on microsites. However, neither SR nor richness of HNV-species were affected by tree-cover, so dense tree-population does not promote SR per se. We did not find significant grazer species

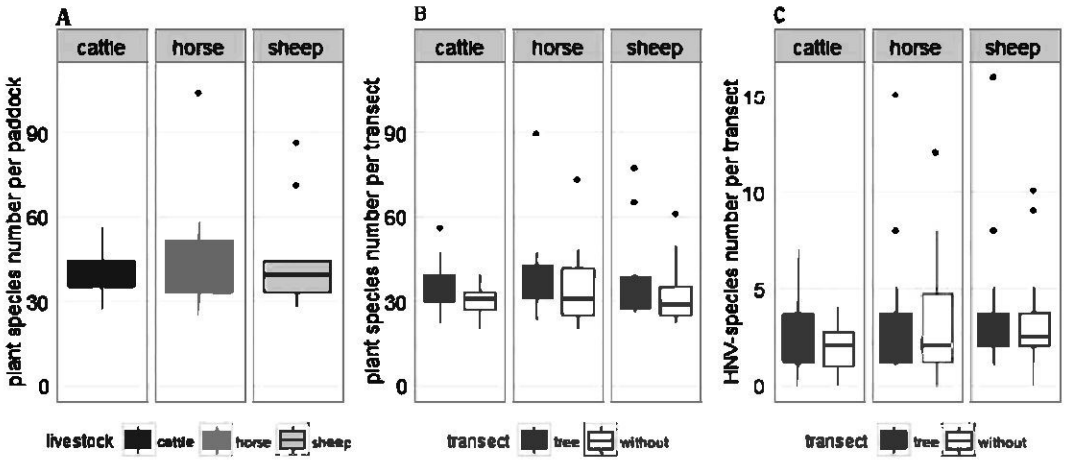

Figure 1. Variability of cumulative number of species per paddock (A) and species richness (B) as well as high nature value species richness (C) on transect scale (areas with trees or without trees), comparing grazer species. Boxplots present upper and lower quartiles around Median.

effects on SR at the transect scale or in cumulative SR per paddock. But there is a remarkable variability and slightly (P<0.07) higher SR in horse grazed paddocks (Figure 1A). However, grazing intensity did affect SR. Models showed a tendency (P<0.07) for a negative influence on SR on transect scale and a significant (P<0.01) negative effect on paddock scale. High stocking rates are known to decrease SR as livestock becomes less selective and tend to homogenize swards (Wrage *et al.*, 2011).

Recent debarking was not common in observed orchards, since only 8% of the analysed trees (n=457) showed it. We did not find differences among grazer species, all grazers significantly increased recent debarking in absence of individual tree-protection (Table 1). Therefore, in short-term grazers debarked a small proportion of tree-population, but the presence of protectors illustrates the importance to avoid future persistent stand damages.

Table 1. Summary of the Generalized Linear Mixed Models fitted for recent debarking as the response variable.

Response variable	Predictors	Importance	Factors	Coeff.	Standard error	z-value	*P*-value
Recent debarking (%)	intercept			-3.575	0.294	11.698	<0.001
	protector	1.00	yes	-1.149	0.532	2.072	0.038
	tree cover	0.20		-0.342	0.503	0.651	0.515
	livestock	0.18	horse	0.284	0.407	0.667	0.505
			sheep	-0.449	0.467	0.920	0.358
	Liveweigth unit	0.17		-1.2e-4	4.5e-4	0.259	0.796

Conclusions

In orchards, maintaining species richness and avoid debarking does not primarily depend upon grazer species, but rather on stocking rates and tree-protection. Therefore, in the absence of cattle or sheep, extensive grazing management with horses might help to maintain orchards. This might be reconsidered in strategies for biodiversity conservation.

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References

Bundesamt für Naturschutz (2016). *Erfassungsanleitung für den HNV-Farmland-Indikator*. Version 7. Bonn, Germany.

Garbarino M. and Bergmeier E. (2014) Plant and vegetation diversity in european wood-pastures. In: Hartel T. and Plieninger T. (eds.) *European Wood-pastures in Transition*. Routledge, New York, pp. 113-131.

Herzog F (1998) Streuobst: a traditional agroforestry system as a model for agroforestry development in temperate Europe. *Agroforestry Systems* 42, 61-80.

Plieninger T., Levers C., Mantel M., Costa A., Schaich H. and Kuemmerle T. (2015) Patterns and Drivers of Scattered Tree Loss in Agricultural Landscapes: Orchard Meadows in Germany (1968-2009*). PLoS ONE* 10(5), e0126178.

Rigueiro-Rodríguez A., McAdam J. and Mosquera-Losada M.R., 2009. *Agroforestry in Europe*. Springer, Berlin, Germany.

Schönhart M., Schauppenlehner T., Schmid E. and Muhar A. (2011*)* Analysing the maintenance and establishment of orchard meadows at farm and landscape levels applying a spatially explicit integrated modelling approach. *Journal of Environmental Planning and Management* 54, 115-143.

Wrage N., Strodthoff J., Cuchillo H., Isselstein J. and Kayser M., (2011): Phytodiversity of temperate permanent grasslands: ecosystem services for agriculture and livestock management for diversity conservation. *Biodiversity Conservation* 20, 3317-3339.